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Soil Outperforms Rice Husk Ash as a Seedling Medium for LUSI Glutinous Rice in Suboptimal Swampy Lands of South Sulawesi, Indonesia

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ABSTRACT

The utilization of vast suboptimal land in Indonesia is important to support food security. Good seedling management is a key strategy in the sustainable utilization of suboptimal land, using soil media (coastal swamps of Lake Tempe (TLS), coastal swamps of the Walanae River (WRS), Telotenreng pumped land (TPL)) and rice husk ash. The objectives of the experiment were to assess the time of shoot formation (days), leaf formation (days), 50% shoot formation (days), seedling height at 8, 15, and 22 days (cm), and the number of plants per tray (plants) in LUSI glutinous rice. The experimental method used RBD with three replications on five types of seedling media: soil media, husk ash media, soil + husk ash 1:1 media, soil + husk ash 2:1 media, and soil + husk ash 1:2 media. The experimental results showed that shoot formation (TLS fast 1.17 days, TLS slow 5.00 days), complete leaf formation (TLS fast 3.00 days, TLS slow 7.33 days), 50% shoots (TLS fast 2.17 days, TLS slow 6.00 days), plant height (WRS tall 33.36 cm, TPL short 8.50 cm), and number of plants per tray (TLS tall 1,385.36 seedlings, WRS short 101.33 seedlings). The conclusion is that the soil medium is the best treatment for all parameters in the three soil medium locations. Therefore, for rice farmers in the suboptimal swampy areas of South Sulawesi, we recommend using local soil as an economically effective seedling medium for LUSI glutinous rice.

1. INTRODUCTION

As the population continues to grow, the demand for food also increases. Indonesia has vast potential for swamp land, including both tidal swamps and lowland swamps [1, 2]. Current agricultural development faces various obstacles, including limited productive land due to conversion to non-agricultural land. Agricultural development will be directed more towards suboptimal non-agricultural land, which is generally found outside Java. The total area of swamp land in Indonesia reaches 34.1 million hectares, of which 25.2 million hectares consists of lowland swamp land and 8.9 million hectares of swamp land. Swamp land is spread across the islands of Sumatra, Papua, Sulawesi, and Kalimantan, with potential for food crops, horticulture, and annual crops [3, 4]. The area of swamp land in Sulawesi is South Sulawesi (218,523 ha), Southeast Sulawesi (87,969 ha), Central Sulawesi (69,412 ha), West Sulawesi (88,937 ha) [4-6].

LUSI is a popular glutinous rice variety released in 1989 with a life span of 130-140 days and a typical yield of 4.5 tons per hectare, with a potential yield of 6.0 tons per hectare, higher than local varieties, with a plant height of 120-130 cm [7]. Suboptimal land, such as that found on the shores of Lake Tempe, South Sulawesi, is land that often faces various challenges for the agricultural sector [8, 9]. These soils generally have low fertility [10], salinity problems due to the influence of seawater [11], and fluctuations in soil moisture due to tidal fluctuations [12] and climatic conditions [13]. Another limiting factor is acidity. Swampy land generally has a pH < 4.5. This high acidity comes from the oxidation of pyrite (FeS_2), which produces sulfuric acid when the soil experiences excessive drying. Slowly decomposed organic matter, which produces organic acids (humic acid, fulvic acid). High rainfall leaching (dissolving and washing away) base cations such as Ca^{2+}, Mg^{2+}, K^+, and Na^+. Decreased soil microbial activity, plant root damage due to overly acidic conditions, decreased electrical conductivity, and cation exchange capacity [3, 8, 9]. Under highly acidic conditions, aluminum and iron ions become highly soluble. Aluminum (Al^{3+}) is toxic to roots, causing them to become short, branch less, and inhibit nutrient absorption [8]. Phosphorus (P) availability is low in swampy soils because, at low pH, Al^{3+} and Fe^{3+} bind with P to form insoluble Al–P and Fe–P compounds. In sulfate-acidic soils, pyrite oxidation reactions further enhance P binding. High kaolinite clay mineral content also binds P. As a result, plants often show symptoms of purple leaves and slow growth. P fertilizer use efficiency is low without amelioration (lime, dolomite, rice husk ash, compost) [3, 8, 10]. Poor drainage, swampy land tends to experience waterlogging that is difficult to drain due to concave topography and low-lying terrain. Low soil permeability, often associated with a high clay fraction and elevated organic matter content, impedes water movement and gas exchange in the soil profile. Moreover, repeated cycles of oxidation and reduction degrade soil structure over time. Poor drainage conditions lead to anaerobic (oxygen-deprived) environments, which significantly inhibit root growth and function [3, 8-10]. These factors can inhibit plant growth and reduce rice productivity [14, 15]. Therefore, a specific strategy is needed to improve rice growth success in this area, one of which is through the use of appropriate seedling media. Seedling media play an important role in the early stages of growth [16, 17]. The right medium will provide optimal support for root development [18, 19], aid nutrient absorption [20, 21], and maintain soil moisture. In suboptimal land, choosing the right seedling medium [22] becomes even more important as it can reduce the negative impact of limited soil conditions.

Ash from rice husk combustion is known as rice husk ash [23]. Because it contains silica, the ash produced from rice husk combustion has pozzolanic properties [24]. Rice husk ash has the function of binding metals. In addition, rice husks serve to loosen the soil [25, 26] so that plant roots can more easily absorb nutrients in the soil. The advantages of using burnt rice husks are that they are sterile, porous, rich in nutrients, and not too light for mobilization [27]. Rice husk ash is an organic material and a compost for soil [28], where the material will serve to improve soil properties and help bind nitrogen, phosphorus, and potassium in the soil [29]. Soil structure can be improved by adding rice husk ash [30]. By reducing soil compaction, the use of rice husks will also improve the physical characteristics of the soil [31]. The disadvantages of rice husk ash are that it is poor in nutrients, dries quickly, and if it is excessive, the roots will not receive enough nutrition [32, 33]. Research on the effect of various growing media on LUSI sticky rice in suboptimal land on the shores of Lake Tempe is highly relevant. This study aims to find the most effective growing medium to support the early growth of LUSI sticky rice in difficult land conditions. By finding the optimal growing medium, farmers in coastal areas can increase crop productivity despite facing environmental limitations. Additionally, it is hoped that this can be a solution to agricultural challenges in other suboptimal lands in Indonesia.

2. MATERIALS AND METHODS

The study was conducted using soil growing media taken from three locations (Talotenreng pumped land (TPL), Walanae River swamp (WRS), and Tempe Lake swamp (TLS)), Figure 1, while rice husk ash growing media was taken from Manurung Village, Bola District, in a broiler chicken farm area, while the sowing location was in Wiringplennae Village, Tempe District. The research period was from August to September 2024.

The materials used were LUSI variety glutinous rice seeds, swamp soil, rice husk ash, NPK fertilizer, and herbicide, while the tools used were rice seedling trays measuring 60 × 30 × 3.5 cm, measuring cups (approx. 1000 ml, Sakti Boro 3.3 brand), a hoe, a bucket, a roll of water hose (100 m), PVC labels for field research, Snowman pens, permanent markers, a notebook, digital scales, scissors, a 4 × 6 m tarp, and a small Shumizu water pump.

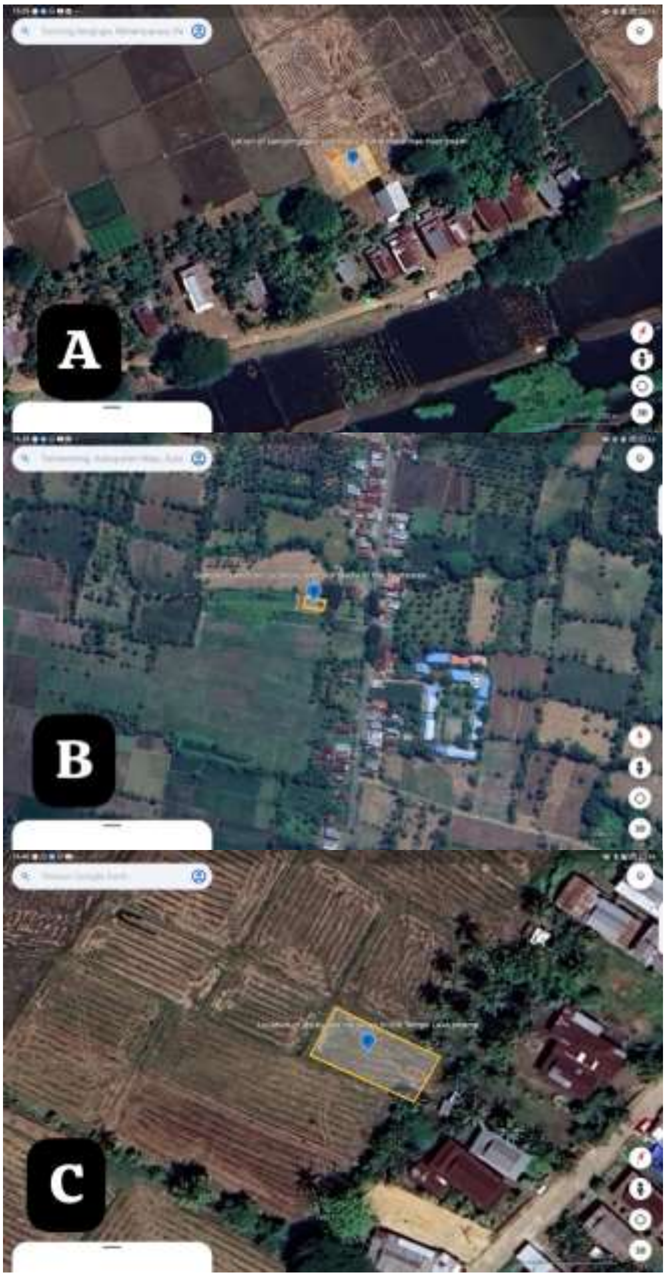

Figure 1. (A) Location of sampling and soil media in the Talotenreng pumped land, (B) Location of sampling and soil media in the Walanae river swampy, (C) Location of sticky rice nurseries in the Tempe lake swampy

This experiment used a randomized block design with five variable media (M), namely soil media (M0), rice husk ash media (M1), soil + rice husk ash 1:1 media (M2), soil + rice husk ash 2:1 media (M3), and soil + rice husk ash 1:2 media (M4). Each variable medium consisted of two rice seedling trays and was replicated three times, so that the number of units at each location was 30 units (5 variable media × 2 seedling trays × 3 replications). The total number of units for the three locations (Tempe Lake swamp, Walanae River swamp, Talotenreng pumped land) was 90 units.

Research data were analyzed using single variance analysis (randomized block design) based on the following linear model:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \quad (1)$$

Y_{ij}: observation results for each variable
μ: general average value
α_i: variety effect
β_j: block effect
ε_{ij}: error effect

When the analysis of variance is significant, the LSD method is used to compare means at the $P < 0.05$ level.

Land preparation by taking soil samples from the Walanae river swamp, Talotenreng pumped land, and Tempe Lake swamp, for soil sample analysis (Table 1) and for planting media, then placing them on trays and watering them until saturated. The soil and water mixture was stirred to approximate actual planting conditions in rice fields. Once the three soil samples were ready, they were placed in seedling trays according to the treatment and combination. Nursery maintenance is carried out by controlling the water in the tarpaulin container (morning and afternoon), when the water is low, then water is added from shallow groundwater (wells). Temperature conditions during the nursery range between 23°C and 30°C. When high temperatures are not a limiting factor in the seedling media and plant growth, they can be balanced by the presence of standing water in the seedling media. Air humidity ranges from 50−85% and can be controlled by the presence of standing water in the nursery. Meanwhile, the lighting around the nursery is not optimal because it is between banana plants. Microclimate control around the nursery can be achieved by the presence of trees in the nursery area.

The parameters observed and measured are: 1. Duration of sprout formation (days), observed from planting until sprouts form. 2. Duration of full leaf formation (days), observed from seedling to sprout formation. 3. Duration of 50% sprout formation (days), observed from planting until 50% of sprouts form. 4. Plant height at 8 days, 15 days, and 22 days, measured from the soil surface to the highest leaf (cm). 5. Number of plants in each rice seedling tray, counted as all plants in each rice seedling tray (plants).

Table 1a. Physical and basic chemical properties of soil samples

Sample Number			Texture (pipet)				Extract 1:2.5		Against Dry Samples 105°C		
									Organic Materials		
Unit	Laboratory	Sampling Site	Sand	Silt	Clay	Texture Class	pH H_2O	Salinity	Walkley & Black C	Kjeldahl N	C/N
			------ % ------					--dS/m--	---- % ----		
1	AS1	TPL	19	35	46	Clay	7.33	2.51	2.25	0.19	12
2	AS2	TLS	21	32	47	Clay	5.87	0.28	2.07	0.21	10
3	AS3	WRS	17	26	57	Clay	7.05	1.85	2.64	0.24	11

Note: 1. TPL: Talotenreng pumping station land, 2. TLS: Tempe Lake swamp, 3. WRS: Walanae River swamp

Table 1b. Cation exchange properties and nutrient content of soil samples

Sample Number			Against Dry Samples 105°C								
			Cation Exchange Rate (NH_4-Acetat 1 N, pH 7)								
Unit	Laboratory	Sampling Site	Ca	Mg	K	Na	Amount	KTK	KB	P_2O_5	K_2O
			----------(cmol(+) kg^{-1}) ----------						%	---mg 100 g^{-1}---	
1	AS1	TPL	8.25	1.05	0.35	0.52	10	29.36	35	41.05	20.14
2	AS2	TLS	5.75	0.85	0.15	0.22	7	28.25	25	29.84	16.32
3	AS3	WRS	6.76	0.74	0.22	0.36	8	26.21	31	32.25	20.74

Note: 1. TPL: Talotenreng pumping station land, 2. TLS: Tempe Lake swamp, 3. WRS: Walanae River swamp

3. RESULTS AND DISCUSSION

3.1 Sprout formation (days)

The results of the experimental evaluation confirm that the growing medium greatly affects the growth of glutinous rice seedlings, in terms of sprout formation parameters in the Tempe Lake swamp (TLS), Walanae River swamp (WRS), and Talotenreng pumped land (TPL) (Table 2). Soil medium was the best among the different media, and the average sprouting time was 1.17 days around TLS, followed by approximately 2.00 days around TPL, followed by 2.17 days in the WRS area. Treatments involving rice husk ash (RHA) or its combination with soil generally led to longer sprouting durations. These differences were statistically significant based on the Least Significant Difference ($LSD_{0.05}$) test.

3.2 Leaf formation (days)

The results of the experimental evaluation confirm that the growing medium significantly affects the growth of glutinous rice seedlings, in terms of leaf formation parameters in the coastal swamp areas of Lake Tempe (TLS), Walanae River (WRS), and Talotenreng pump area (TPL) (Table 3). Soil medium was the best among the other media, and the average leaf formation was 3.00 days at the TLS location, followed by the TPL and WRS locations, each with 3.50 days. Treatments involving rice husk ash (RHA) or its combination with soil generally led to longer sprouting durations. These differences were statistically significant based on the Least Significant Difference ($LSD_{0.05}$) test.

3.3 Shoot formation 50% (days)

The results of experimental evaluations in Table 4 prove that the planting media significantly increased the growth of sticky rice seedlings, with a parameter of 50% shoot formation in the Tempe Lake coastal swamp area (TLS), the Walanae River coastal swamp area (WRS), and the Talotenreng pump area (TPL). Treatments involving rice husk ash (RHA) or its combination with soil generally led to longer sprouting durations. These differences were statistically significant based on the Least Significant Difference ($LSD_{0.05}$) test.

Table 2. Formation of LUSI glutinous rice shoots at planting locations

Planting Locations	Analysis of Variance	Effect of Planting Media					$LSD_{0.05}$
		Soil (M_0)	RHA (M_1)	Soil + RHA 1:1 (M_2)	Soil + RHA 2:1 (M_3)	Soil + RHA 1:2 (M_4)	
TLS	30.71**	1.17 ^{a}	5.00 ^{d}	3.67 ^{c}	2.50 ^{b}	4.00 ^{cd}	0.77
WRS	54.63**	2.17 ^{a}	4.33 ^{b}	2.50 ^{a}	2.33 ^{a}	4.33 ^{b}	0.49
TPL	26.74**	2.00 ^{a}	4.67 ^{b}	2.50 ^{a}	2.67 ^{a}	4.33 ^{b}	0.75

Note: 1. TLS: Tempe Lake Swamp; 2. WRS: Walanae River Swamp; 3. TPL: Talotenreng Pumping Station Land; 4. RHA: Rice husk ash; 4. Different letters in the same row indicate significant differences at the P < 0.05 level.

Table 3. Leaf formation of LUSI glutinous rice at planting sites

Planting Locations	Analysis of Variance	Effect of Planting Media					$LSD_{0.05}$
		Soil (M_0)	RHA (M_1)	Soil + RHA 1:1 (M_2)	Soil + RHA 2:1 (M_3)	Soil + RHA 1:2 (M_4)	
TLS	146.24**	3.00 ^{a}	7.33 ^{c}	3.17 ^{a}	3.33 ^{a}	5.17 ^{b}	0.45
WRS	63.42**	3.50 ^{a}	7.17 ^{c}	3.67 ^{a}	3.67 ^{a}	5.83 ^{b}	0.68
TPL	68. 67**	3.50 ^{a}	7.17 ^{c}	3.67 ^{a}	3.67 ^{a}	5.50 ^{b}	0.63

Note: 1. TLS: Tempe Lake Swamp; 2. WRS: Walanae River Swamp; 3. TPL: Talotenreng Pumping Station Land; 4. RHA: Rice husk ash; 4. Different letters in the same row indicate significant differences at the P < 0.05 level.

Table 4. Shoot formation of LUSI glutinous rice at 50% at planting sites

Planting Locations	Analysis of Variance	Effect of Planting Media					$LSD_{0.05}$
		Soil (M_0)	RHA (M_1)	Soil + RHA 1:1 (M_2)	Soil + RHA 2:1 (M_3)	Soil + RHA 1:2 (M_4)	
TLS	30.71**	2.17 ^{a}	6.00 ^{d}	4.67 ^{c}	3.50 ^{b}	5.00 ^{c}	0.77
WRS	57.25**	3.17 ^{a}	5.33 ^{b}	3.33 ^{a}	3.33 ^{a}	5.33 ^{b}	0.49
TPL	33.99**	3.00 ^{a}	5.67 ^{b}	3.50 ^{a}	3.50 ^{a}	5.33 ^{b}	0.68

Note: 1. TLS: Tempe Lake Swamp; 2. WRS: Walanae River Swamp; 3. TPL: Talotenreng Pumping Station Land; 4. RHA: Rice husk ash; 4. Different letters in the same row indicate significant differences at the P < 0.05 level.

Table 5. Seedling height of LUSI glutinous rice at planting sites

Planting Locations	Analysis of Variance	Effect of Planting Media					$LSD_{0.05}$
		Soil (M_0)	RHA (M_1)	Soil + RHA 1:1 (M_2)	Soil + RHA 2:1 (M_3)	Soil + RHA 1:2 (M_4)	
TLS							
Aged 8 DAS	69.54**	12.85 ^{a}	4.26 ^{c}	9.91 ^{b}	12.65 ^{a}	9.90 ^{b}	1.20
Aged 15 DAS	36.07**	22.35 ^{a}	8.78 ^{d}	17.73 ^{bc}	19.79 ^{ab}	16.03 ^{c}	2.48
Aged 22 DAS	62.02**	32.03 ^{a}	8.94 ^{d}	26.99 ^{b}	28.97 ^{b}	17.26 ^{c}	3.51
WRS							
Aged 8 DAS	11.68**	11.91 ^{a}	4.18 ^{b}	10.50 ^{a}	10.49 ^{a}	7.06 ^{b}	3.01
Aged 15 DAS	28.16**	23.29 ^{a}	7.04 ^{d}	17.08 ^{bc}	18.67 ^{b}	14.52 ^{c}	3.68
Aged 22 DAS	37.42**	33.36 ^{a}	9.21 ^{d}	24.08 ^{b}	26.18 ^{b}	18.05 ^{c}	4.84
TPL							
Aged 8 DAS	53.66**	11.13 ^{a}	3.36 ^{c}	10.87 ^{a}	10.27 ^{a}	7.78 ^{b}	1.45
Aged 15 DAS	76.25**	22.18 ^{a}	7.96 ^{d}	20.98 ^{ab}	19.62 ^{b}	14.97 ^{c}	2.17
Aged 22 DAS	27.38**	30.78 ^{a}	8.50 ^{c}	27.92 ^{a}	26.47 ^{ab}	21.29 ^{b}	5.49

Note: 1. TLS: Tempe Lake Swamp; 2. WRS: Walanae River Swamp; 3. TPL: Talotenreng Pumping Station Land; 4. RHA: Rice husk ash; 5. DAS: Day After Seedling. Different letters in the same row indicate significant differences at the P < 0.05 level.

3.4 Seedling height (cm)

The results of the experimental evaluation in Table 5 and Figure 2 show that the growing medium significantly increased the growth of glutinous rice seedlings in terms of peak plant growth parameters (at 8, 15, and 22 days after planting) in the coastal swamp areas of Lake Tempe (TLS), Walanae River (WRS), and Talotenreng pump area (TPL). Soil media was of high quality among the different media, and the general peak of 8-day-old flowers was 12.85 cm in the TLS area, observed through the WRS area at 11.91 cm, and the next TPL area at 11.13 cm, while the 15-day-old age was 23.29 cm in the WRS area, observed through the TLS area at 22.35 cm, followed by 22.18 cm in the TPL area. At 22 days old, the peak height was 33.36 cm in the WRS area, 32.03 cm in the TLS area, and 30.78 cm in the TPL area (LSD test at 95%). This indicates that flower peaks in soil medium tend to be higher than in rice husk ash. Further comparison of the morphology of LUSI glutinous rice seedlings at 22 days after treatment (Figure 3), and the condition of LUSI glutinous rice seedlings before harvest and ready for planting (Figure 4).

3.5 Number of plants per tray (seedlings)

The results of the experimental evaluation in Table 6 show that soil medium is the best variable with the highest value for the parameter of number of plants per tray (seedlings) in the TLS, WRS, and TPL. The soil medium produced the highest number of seedlings compared to other media. The highest among the three soil samples was 1,385.83 seedlings in the TLS area, followed by the TPL area with 1,219.17 seedlings, and the WRS area with 1,196.67 seedlings (LSD Test at 95%).

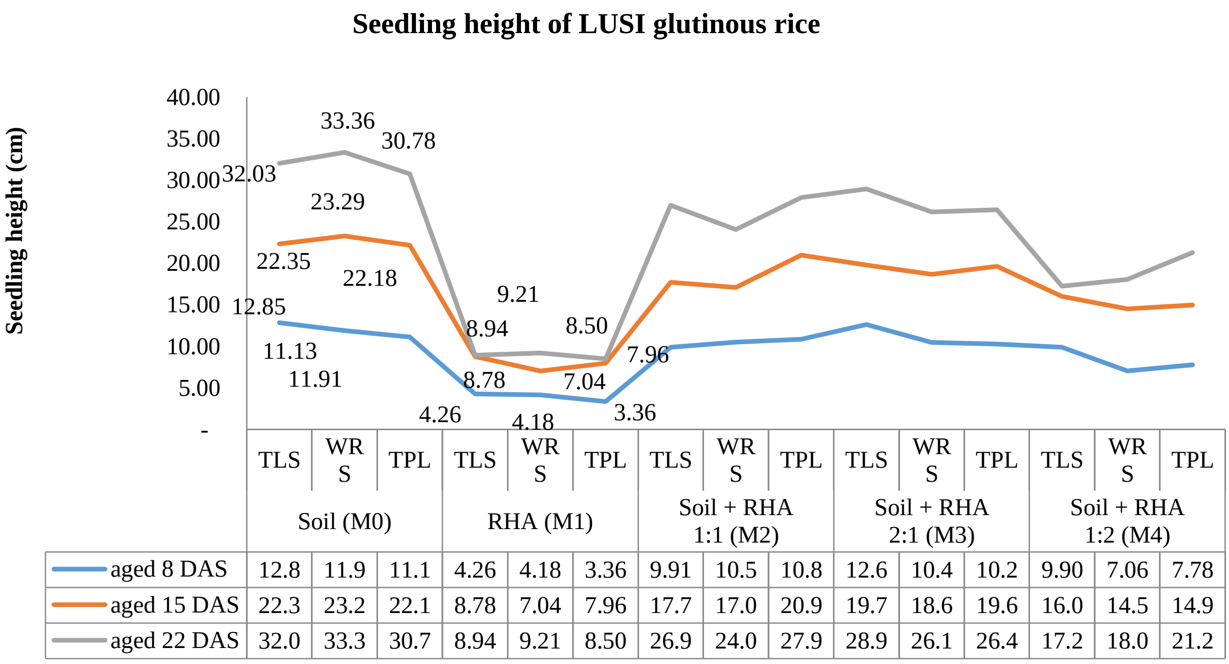

Figure 2. Seedling height of LUSI glutinous rice at planting sites

Note: 1. TLS: Tempe Lake swamp; 2. WRS: Walanae River swamp; 3. TPL: Talotenreng pumping station land; 4. RHA: Rice husk ash; 5. DAS: Day After Seedling

Figure 3. Comparison of the morphology of LUSI glutinous rice seedlings at 22 days after treatment. (A) Soil media (M_0), (B) Rice husk ash media (M_1), (C) Soil + rice husk ash 1:1 media (M_2), (D) Soil + rice husk ash 2:1 media (M_3), and (E) Soil + rice husk ash 1:2 media (M_4)

Figure 4. Condition of LUSI glutinous rice seedlings. (A) Before harvest and (B) Ready for planting

The results of the soil analysis (Table 1) indicate that the three planting locations are categorized as moderately suitable to very suitable to support increased rice production [34]. The soil media at the three locations—TLS, WRS, and TPL—inherently have good fertility, due to their edaphic characteristics that support basic soil fertility [35-39]. Several supporting factors include: Swamp environment and organic matter enrichment. Swamp ecosystems naturally receive high biomass inputs from aquatic vegetation, litter, and plant residues. The slow anaerobic decomposition process causes the long-term accumulation of organic matter. This organic matter increases cation exchange capacity (CEC), and provides macronutrients (N, P, K) and micronutrients, and improves soil structure and water retention [35-39]. The Lake Tempe area is a dynamic hydrological system. Annual sedimentation carries minerals from the catchment areas in the surrounding hills. This mineral-rich sedimentation makes the soil relatively fertile and less nutrient-poor than peat swamps [35, 36]. The mineral swamps in Lake Tempe do not have the extreme acidity levels of peat swamps. The relatively near-neutral pH supports phosphate availability, stable ammonium nitrogen availability, and optimal nutrient uptake. These conditions create an ideal environment for early root development of rice seedlings. All of these factors explain why M_0 (pure soil) provided the best and most consistent response in seedling growth parameters. M_0 excelled because the soils in all three swamp locations have inherently high fertility [34-46].

Pure rice husk ash (M_1) has significant physical and chemical limitations. The limitations of physical properties are: Rice husk ash has very high Porosity causing water to absorb quickly so that the seeds experience physiological drought, and Low bulk density resulting in difficulty supporting the roots, causing shallow and unstable roots [44], and very low water retention capacity so that the media dries quickly and interferes with the initial hydration of the sprouts [32, 44]. As a result, the root environment is unable to maintain the moisture necessary for germination and shoot formation [32, 35, 36, 41, 47, 48]. The limitations of chemical properties are: Despite its high silica (Si) content, rice husk ash has very low N, P, and K content, and provides almost no essential micronutrients, and does not have adequate cation exchange capacity to bind and store nutrients. As a result, seedlings grown in M_1 experience nutritional deficiencies from the start, characterized by slow growth, pale leaves, and a small number of shoots (Figure 3) [32, 35, 36, 41, 45, 47, 48].

Table 6. Number of LUSI glutinous rice seedlings per tray at planting sites

Planting Locations	Analysis of Variance	Effect of Planting Media					$LSD_{0.05}$
		Soil (M_0)	RHA (M_1)	Soil + RHA 1:1 (M_2)	Soil + RHA 2:1 (M_3)	Soil + RHA 1:2 (M_4)	
TLS	39.81**	1385.83 ^{a}	119.83 ^{c}	927.50 ^{b}	1062.50 ^{b}	355.83 ^{c}	238.96
WRS	5.71*	1196.67 ^{a}	101.33 ^{b}	916.67 ^{a}	841.67 ^{a}	840.00 ^{a}	554.48
TPL	13.73**	1219.17 ^{a}	360.17 ^{c}	1040.83 ^{a}	1005.83 ^{a}	675.83 ^{b}	300.67

Note: 1. TLS: Tempe Lake Swamp; 2. WRS: Walanae River swamp; 3. TPL: Talotenreng pumping station land; 4. RHA: Rice husk ash. Different letters in the same row indicate significant differences at the $P < 0.05$ level.

This combination of deficiencies causes the seedlings' energy to be spent on survival, rather than forming new tissue, and photosynthesis rates are low due to low N and Mg supplies, as well as delayed shoot and leaf formation. This is why M_1 is consistently the worst-performing treatment, because it is poor in nutrients and unable to retain water [32, 35, 36, 41, 45, 47, 48].

The 2:1 soil + rice husk ash treatment (M_3) performed similarly to pure soil (M_0). The 2:1 ratio (two parts soil: one part rice husk ash) represents the optimum balance between the benefits and limitations of rice husk ash [35, 36, 42, 46]. The mechanisms that enable M_0-equivalent performance are aeration properties, and the improvement mechanism in rice husk ash improves soil pore space, leading to healthier roots. The resulting soil, which is moist yet not excessively wet, arises from the soil's ability to retain water, the improvement in the soil mixture's water storage capabilities, and the role of rice husk ash in regulating soil aeration [42]. The nature of lower bulk density, the repair mechanism in the roots more easily penetrates the rice husk ash media, thus accelerating the growth of primary roots [47]. The rooting environment is balanced, with a combination of good physical structure and repair mechanisms, without significant nutrient loss from the soil. With a 2:1 ratio, the soil component remains dominant, preventing loss of its chemical fertility, while the rice husk ash provides physical benefits to the medium. Therefore, M_3 is an ideal compromise, enough soil for nutrients, enough rice husk ash for physical repair, resulting in performance similar to M0 [33, 35, 36, 38, 41-45, 49, 50].

The soil + rice husk ash 2:1 treatment (M_3) was not significantly different from the soil treatment (M_0) in various early plant growth indicators, such as: shoot formation (days), leaf formation (days), 50% shoot formation (days), seedling height at 22 days after planting, and the number of plants per tray. This is greatly influenced by the initial nutrient status and root condition. The reason: Soil as the main nutrient provider is still dominant in M_3, so that the seedlings receive almost the same nutrient supply as M_0 [35, 36]. Rice husk ash only acts as a physical modifier, not a source of nutrients, so it does not significantly change the nutritional function [45, 49, 51]. In the early growth phase, the plant's nutrient requirements are still relatively low, so the additional water retention and aeration from rice husk ash do not result in a drastic growth spurt [50]. There was no significant physical or chemical stress in M_3, in contrast to the physically extreme and nutrient-poor M_1. Therefore, the plant response in M_3 was close to that of M_0, resulting in a 95% LSD analysis showing no significant differences. Therefore, the insignificant differences between M_3 and M_0 in all initial growth indicators indicate that mild physical modification without soil reduction was not strong enough to produce statistically different agronomic responses [35, 36, 38, 43-45, 49-51].

4. CONCLUSION

Based on the evaluation, soil media is a variable that has a significant impact on all parameters (shoot formation, ideal leaf formation, 50% shoot variation, plant growth peaks at 8, 15, and 22 days, and number of seedlings per tray) at 3 locations (TLS, WRS, and TPL). The soil medium variables and the soil medium + rice husk ash 2:1 variable were satisfactory and had an impact at the TLS, WRS, and TPL locations for the parameters of ideal leaf formation and plant peak at 8, 15, and 22 days after planting. Meanwhile, the parameters of shoot formation, 50% shoot variation, and vegetation variation according to rice seedling trays were satisfactory and had an impact on the WRS and TPL locations. This study only assessed the seedling stage; the impact of these media treatments on the final yield after transplanting requires further field experiments for verification.

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REFERENCES

[1] Dahiri. (2019). Potential, challenges, and support the optimization swamp into the rice field to the sovereignty of food. Jurnal Budget, 4(1). https://berkas.dpr.go.id/pa3kn/jurnal-budget/public-

file/jurnal-budget-public-8.pdf.
[2] Budiastuti, M.T.S., Setyaningrum, D., Supriyono, Fahma, A.S. (2025). Effects of water stress and goat manure fertilizer on the growth and yield of upland rice in Indonesia. International Journal of Design & Nature and Ecodynamics, 20(7): 1605-1613. https://doi.org/10.18280/ijdne.200717
[3] Sosiawan, H., Muhammad. (2018). Annual report of the swamp land agriculture research center 2017. Balai Penelitian Pertanian Lahan Raw, Banjarbaru. https://rawa.brmp.pertanian.go.id/informasi-publik/laporan-tahunan.
[4] Masganti, M., Saleh, M., Abduh, A.M., Agustina, R., Hairani, A. (2023). Amelioration of type B tidal swamp land and its effect on hybrid rice productivity. Jurnal Agrotek Tropika, 11(4): 695-704. http://doi.org/10.23960/jat.v11i4.6901
[5] Maruapey, A., Utami, D., Wicaksana, N., Karuniawan, A. (2023). Performance of rice hope lines in the Lebak shallow swamp Sorong Regency, Southwest Papua. Median: Jurnal Ilmu Ilmu Eksakta, 15(2): 88-98. http://doi.org/10.33506/md.v15i2.2615
[6] Maruapey, A., Nurlela, N., Lisaholit, S., Wardani, K.D.K., Ryadin, W. (2023). Farmer assistance through swamp rice cultivation practices in Makbalim Village, Mayamuk District, Sorong Regency, PBD. ABDIKAN Jurnal Pengabdian Masyarakat Bidang Sains dan Teknologi, 2(1): 44-49. https://doi.org/10.55123/abdikan.v2i1.1656
[7] Suyatno, Rusmanadi, Supeno, I., Suharsono, S., Harahap, Z. (2023). Food crop seed celebration in 2023. In Dinas Pertanian dan Ketahanan Pangan Daerah Istimewa Yogyakarta, Food Crop Seed Celebration. pp. 104-116. https://dpkp.jogjaprov.go.id/unduh/e8c886e9da0d72ab0a0d96f1950e516f4ab8ac3f1485253bd7745a8ae103259d220.
[8] BAPPENAS. (2021). Sustainable swamp development and management. Gedung Perpustakaan Pusat ITB. https://www.dsdan.go.id/mdocs-posts/rekomendasi-pengelolaan-rawa-berkelanjutan-untuk-mnedukung-pangan-matriks-2020.
[9] Khairullah, I., Alwi, M., Annisa, W., Mawardi. (2021). The fluctuation of rice production of tidal swampland on climate change condition (Case of South Kalimantan Province in Indonesia). IOP Conference Series: Earth and Environmental Science, 724(1): 012009. https://doi.org/10.1088/1755-1315/724/1/012009
[10] Husna, M., Nofrianti, T., Anggraini, S., Prameswari, W., Salamah, U. (2024). Potential of biofertilizer to increase rice yields in swamp lands. Jurnal Ilmu-Ilmu Pertanian Indonesia, 26(1): 48-53. https://doi.org/10.31186/jipi.26.1.48-53
[11] Jaroo, S.S., M-Ridha, M.J. (2025). Performance analysis of a double anode-desalination photosynthetic microbial desalination cell under varying nutrient and saline water conditions. International Journal of Design and Nature and Ecodynamics, 20(3): 479-487. https://doi.org/10.18280/ijdne.200303
[12] Sabran, M., Darsani, Y.R., Qomariah, R., Susilawati, Rozi, F., Lesmayati, S. (2025). Technical efficiency of rice production in tidal swampland: A stochastic model approach. International Journal of Design and Nature and Ecodynamics, 20(4): 715-722. https://doi.org/10.18280/ijdne.200403
[13] Hairani, A., Alwi, M., Noor, M., Saleh, M., Khairullah, I., Wakhid, N. (2023). Rice productivity on the swampland flooded tide: The case of Terusan Karya Village. E3S Web of Conferences, 444: 04013. https://doi.org/10.1051/e3sconf/202344404013
[14] Michael, P.S., Mwakyusa, L., Sanga, H.G., Shitindi, M.J., Kwaslema, D.R., Herzog, M. (2023). Floods stress in lowland rice production: experiences of rice farmers in Kilombero and Lower-Rufiji floodplains, Tanzania. Frontiers in Sustainable Food Systems, 7: 1206754. https://doi.org/10.3389/fsufs.2023.1206754
[15] Abdillah, M.R., Yamin, M., Yunita. (2024). The level of risk of rice farming due to the flood disasters experienced by rice farmers on swamp Lebak lands in Pemulutan Subdistrict Ogan Ilir Regency. World Journal of Advanced Research and Reviews, 23(1): 2833-2835. https://doi.org/10.30574/wjarr.2024.23.1.2249
[16] Pandiangan, S., Trina, S.T., Saragih, S. (2018). Response of rice (Oryza sativa L.) on seedling age and number of seedlings per planting hole. IOP Conference Series: Materials Science and Engineering, 420: 012082. https://doi.org/10.1088/1757-899X/420/1/012082
[17] Ekasari, I., Lailati, M., Nurlaeni, Y., Puspanti, A., Mufida, Y.R. (2025). Seed morphology and seedling growth modeling for Litsea cordata and Sloanea sigun in Java montane forests. International Journal of Design and Nature and Ecodynamics, 20(3): 547-554. https://doi.org/10.18280/ijdne.200310
[18] Gao, Y., Zhu, Y., Zhang, Y., Zhang, Y., Wang, Y., Wang, Z. (2023). Physiological characteristics of root regeneration in rice seedlings. Agronomy, 13(7): 1772. https://doi.org/10.3390/agronomy13071772
[19] Rachmawati, D., Maryani, M.M., Kusumadewi, S., Rahayu, F. (2019). Survival and root structure changes of rice seedlings in different cultivars under submergence condition. Biodiversitas, 20(10): 3011-3017. https://doi.org/10.13057/biodiv/d201033
[20] Purba, T., Ningsih, H., Purwaningsih, Junaedi, A.S., Gunawan, B., Junairiah. (2021). Soil and Plant Nutrition. Yayasan Kita Menulis. https://dosen.unmerbaya.ac.id/file/content/2022/03/tanah_dan_nutrisi_tanaman_gunawan.pdf.
[21] Sugianto, S., Jayanti, K.D. (2021). The effect of planting media composition on the growth and yield of red onions. Agrotechnology Research Journal, 5(1): 38-43. https://doi.org/10.20961/agrotechresj.v5i1.44619
[22] Hamzah, H., Hardiyanti, R.A., Handayani, R., Rumondang, J., Utari, I.T. (2024). Effect of adding various organic ingredients to the media planting sub soil for growth Petai seeds (Parkia speciosa). Jurnal Silva Tropika, 8(1): 41-51. https://online-journal.unja.ac.id/STP/article/view/35826/18561.
[23] Riono, Y., Apriyanto, M. (2020). Utilization of rice husk ash in mung bean (Vigna radiate L) fertilizer innovation in peat land. Selodang Mayang Jurnal Ilmiah Badan Perencanaan Pembangunan Daerah Kabupaten Indragiri Hilir, 6(2): 60-69. https://doi.org/10.47521/selodangmayang.v6i2.164
[24] Terkelin, P. (2021). Study of Jajar Legowo system and addition of rice husk ash on the intensity of stem borer pest attacks. AgriHumanis: Jurnal Agri Human Resources Development Studies, 2(2): 95-108. https://doi.org/10.46575/agrihumanis.v2i2.91
[25] Mapegau, M., Setyaji, H., Hayati, I., Ayuningtiyas, S.P.

(2022). Effects of rice husk biochar residue and chicken manure on growth and yield of corn (Zea mays L.). Biospecies, 15(1): 49-55. https://doi.org/10.22437/biospecies.v15i1.17121
[26] Novianti, T., Mustamu, N.E., Walida, H., Syawal, Harahap, F. (2022). The effect of rice husk charcoal planting media composition on the growth and production of glutinous corn (Zea mays ceratina L.). Jurnal Mahasiswa Agroteknologi, 3(1): 1-7. https://jurnal.ulb.ac.id/index.php/JMATEK/article/view/2844.
[27] Zhang, Y., Chen, H., Xiang, J., Xiong, J., Wang, Y., Wang, Z. (2022). Effect of rice-straw biochar application on the acquisition of rhizosphere phosphorus in acidified paddy soil. Agronomy, 12(7): 1556. https://doi.org/10.3390/agronomy12071556
[28] Adnan, R.T., Suharti, W.S., Suwarto. (2022). Effect of rice husk ash on the growth and resistance of three upland rice varieties infected with Rhizoctonia solani. Agronomi: Jurnal Budidaya Pertanian Berkelanjutan, 12(1): 21-31. https://www.scribd.com/document/946390962/Document.
[29] Putra, A.T., Ekawati, R. (2023). Rice husk ash and wood charcoal as an alternative top soil for oil palm seedling planting media in pre-nursery. Agroteknika, 6(2): 149-160. https://doi.org/10.55043/agroteknika.v6i2.204
[30] Adawiyah, R., Safuan, L.O., Arma, M.J., Nurmas, A., Pakki, T. (2023). Determination of rice husk ash dosage as a planting medium in shallot cultivation (Allium ascalonicum L.). In Prosiding Seminar Nasional Pembangunan dan Pendidikan Vokasi Pertanian Politeknik Pembangunan Pertanian Manokwari, pp. 577-586. https://doi.org/10.47687/snppvp.v4i1.681
[31] Lamasrin, S., Deibij, D., Ogie, T.B. (2023). The effect of the application of media for burnt husks on the growth of mustard plants (Brassica juncea L.). Jurnal Agroekoteknologi Terapan, 4(2): 329-337. https://ejournal.unsrat.ac.id/index.php/samrat-agrotek.
[32] Teutscherová, N., Vázquez, E., Drábek, O., Hutla, P., Kolaříková, M., Banout, J. (2023). Disentangling the effects of rice husk ash on increased plant growth and nitrogen recovery. Geoderma, 437: 116577. https://doi.org/10.1016/j.geoderma.2023.116577
[33] Masulili, A., Irianti, A.T.P., Abdurrahman, T., Suci, U. (2024). Rice plant growth in two planting periods on acid sulfate soil with rice husk biochar treatment and several organic amendments. Agrikultura, 35(2): 377-386. https://doi.org/10.24198/agrikultura.v35i2.55752
[34] Budianto, Y., Tjoneng, A., Ibrahim, B. (2022). The evaluation of land suitability for rice plants (Oryza sativa L.) in Herlang District, Bulukumba. Jurnal AGrotekMAS, 2(3): 29-36. https://jurnal.fp.umi.ac.id/index.php/agrotekmas.
[35] Raizada, E.M.N. (2018). Encyclopedia of subsistence farming solutions (SAKpedia, 2018 edition). University of Guelph, Canada. http://hdl.handle.net/10625/57144.
[36] Council, A.W. (2023). Guidelines for brackish water use for agricultural production in the Near East and North Africa region. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cc3234en
[37] Asrijal, A., Rahmawati, R., Upe, A. (2022). Test of water hyacinth bokashi and plant growth regulator on black rice plants. Agrotech Journal, 7(1): 33-42. https://doi.org/10.31327/atj.v7i1.1754
[38] Upe, A., Asrijal, A. (2021). The use of various concentrations of organic biological fertilizers on the growth and production of rice (Oryza sativa L.). Jurnal TABARO, 5(1): 543-549. https://doi.org/10.35914/tabaro.v5i1.764
[39] Asrijal, A., Sapareng, S., Upe, A., Akmal, A., Arzan, A.R.T.S. (2023). Testing of plant growth regulator and organic fertilizers on black rice plants. Jurnal Teknik Pertanian Lampung, 12(2): 484-494. http://doi.org/10.23960/jtep-l.v12i2.484-494
[40] Maruapey, A., Soekamto, M.H. (2022). Growth and yield of melon plants (Cucumis melo L.) at various doses of bokashi organic fertilizer from rice straw agricultural waste. Jurnal Agribisnis Perikanan, 15(1): 129-139. https://doi.org/10.52046/agrikan.v15i1.129-139
[41] Sorum, M.G., Kalita, A. (2023). Effect of bio-cementation with rice husk ash on permeability of silty sand. Civil Engineering Journal, 9(11): 2854-2867. http://doi.org/10.28991/CEJ-2023-09-11-016
[42] De la Rosa, J.M., Pérez-Dalí, S.M., Campos, P., Sánchez-Martín, Á., González-Pérez, J.A., Miller, A.Z. (2023). Suitability of volcanic ash, rice husk ash, green compost and biochar as amendments for a Mediterranean alkaline soil. Agronomy, 13(4): 1097. https://doi.org/10.3390/agronomy13041097
[43] Saranya, P., Gayathiri, C.M.S., Sellamuthu, K.M. (2018). Potential use of rice husk ash for enhancing growth of maize (Zea mays). International Journal of Current Microbiology and Applied Sciences, 7(3): 899-906. https://doi.org/10.20546/ijcmas.2018.703.105
[44] Dauda, A., Ibrahim, A.S., Idris, A., Zayyan, M.A. (2022). Effect of rice husk ash with coconut husk ash on geotechnical properties of lateritic soil. Journal of Invention Engineering and Technology, 2(2): 30-40.
[45] Budianta, D., Febriana, E., Fitri, S.N.A. (2022). Application of cow manure combined with rice husk ash to increase soybean (Glycine max (L.) Merr) production in Indonesia Ultisol. Journal of Environmental Science and Engineering B, 11(2): 49-59. https://doi.org/10.17265/2162-5263/2022.02.004
[46] Abdullah, S.A., Khalaf, A.S. (2024). Influence of target seeding rates based on thousand kernel weight on vegetative growth traits of triticale, variety Admiral- Part I. Iraqi Journal of Agricultural Sciences, 55(5): 1838-1847. https://doi.org/10.36103/77kmp732
[47] Mot, S., Khin, S., Peuo, V., Pok, P., Srean, P. (2021). Rice husk ash incorporation in container substrates effect on romaine lettuce plant growth. Agritropica: Journal of Agricultural Sciences, 4(1): 30-37. https://doi.org/10.31186/Jagritropica.4.1.30-37
[48] Murniati, N., Bimasri, J., Agustina, K., Holidi. (2022). Morphological performance of white glutinous rice (Oryza sativa glutinous L.) local varieties of Musi Rawas Regency resulted from irradiation. In Prosiding Seminar Nasional Peripi 2022 "Link-Match" Ilmu Pemuliaan untuk Peningkatan Daya Saing Agro Industri Indonesia, pp. 133-142. https://peripi.org/wp-content/uploads/2023/07/12.pdf.
[49] Li, M., Ning, X., Gao, T., Fazry, S., Othman, B.A., Abdul, A. (2024). Rice husk ash based growing media impact on cucumber and melon growth and quality. Scientific Reports, 14: 5147. https://doi.org/10.1038/s41598-024-55622-4
[50] Syafrizal, Y., Sevirasari, N., Adileksana, C., Plena,

S.N.G. (2024). Effects of rice husk mulch dosage on the growth and yield of corn. Ilmu Pertanian (Agricultural Science), 9(2): 102-115. https://doi.org/10.22146/ipas.93787

[51] Gomez, K.A., Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd ed.). John Wiley & Sons. https://pdf.usaid.gov/pdf_docs/pnaar208.pdf.